Original Research Article

Emergence and incidence of coffee white stemborer, *Xylotrechus quadripes* Chevrolat, 1863 (Coleoptera: Cerambycidae), under different rainfall regimes across the coffee-growing regions of Karnataka, India

ABSTRACT

. The coffee white stem borer (CWSB), *Xyloterchus quadripes* Chevrolat, 1863 (Coleoptera: Cerambycidae) is one of the most destructive pests of arabica coffee in India. As coffee cultivation in India is mostly confined to the hilly tracts of the Western Ghats of the southern states and it is mainly grown in Kodagu, Chikmagalur and Hassan districts of Karnataka with varying rainfall patterns ranging from more than 3000 mm to less than 1000 mm. The study of the incidence of WSB and emergence of adults in relation to local weather conditions in the estates at different rainfall patterns in Karnataka [High(<2500mm), Medium (2000 to 1000mm) and low(<1000mm) rainfall areas] for two years (2016 and 2017). The emergence data and local weather parameters viz rainfall, relative humidity and temperature were correlated with adult emergence. The results indicated that the emergence of CWSB during the years 2016 and 2017 exhibited a significant positive correlation with maximum temperature and minimum temperature. While beetle emergence was negatively correlated with the quantity of rainfall and relative humidity across the six locations. From these observations, it is evident that the beetles required a higher temperature for their emergence and peak beetle emergence occurred during the middle of November in the winter flight season and during the end of April and the first fortnight of May in the summer flight periods. Multiple linear regression analysis revealed that measured a biotic factors have significant effects on emergence of CWSB adults confirming results of correlation analysis. During the same period 2016-17, coffee plantations were surveyed randomly in all the three rainfall regimes to know the influence of annual rainfall on incidence of CWSB and the percent incidence was 10.81 at rainfall <1000, 7.67 at medium rainfall and 6.16 at high rainfall areas and was non-significant across rainfall regimes.

Keywords: Arabica Coffee, coffee White Stem Borer, *Xyloterchus quadripes*, Emergence pattern, flight period, incidence survey, incidence weather correlation,

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1. Introduction :

Coffee is an introduced crop into India from Africa. Arabica,*Coffea arabica* L. (Rubaceae) and Robusta, *Coffea canefora* Pierre ex Froehner (Rubaceae) are the two commercially grown coffee species in India. As coffee cultivation in India is mostly confined to the hilly tracts of the Western Ghats of the southern states viz., Karnataka, Kerala and Tamil Nadu. It is also grown to a small extent in Andrapradesh and some North Eastern states. Whereas 70 percent of coffee is produced in Karnataka state. Coffee belt of Karnataka includes parts of three districts - Kodagu, Chickmagalore and Hassan (1).

The coffee white stem borer, *Xyloterchus quadripes* Chevrolat, 1863, (Coleoptera: Cerambycidae) is one of the most destructive pests of arabica coffee plants in all coffee growing areas of India. While robusta coffee is free from *X. quadripes* attack (4). *X. quadripes* is a major pest in Arabica coffee plantations in India, Thailand, Sri Lanka, Vietnam and China (6, 9, 16).

Studies on the emergence pattern of *X. quadripes* have shown that the adult beetles have two flight periods in a year *viz*., April to May and October to November (10, 14). There is also mention that the pre-monsoon flight begins in April and extends to the end of May and the post-monsoon flights begin by the end of September and extend to the end of December or the middle of January (5, 11). Whereas in Vietnam recorded the greatest number of beetles emergence in May, June and July when the temperature was high but smaller numbers also appeared in February to March and November to December (2).

With the change in weather conditions in recent years, the emergence pattern has been varying but limited information is available on the influence of weather factors on adult emergence from different regions of coffee growing tracts in India (15). By considering the above views, the present study on the emergence pattern of *X. quadripes* in relation to weather in different climatic regions was carried out.

2. Materials and methods:

2.1 Emergence pattern under different rainfall regimes

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The study on the emergence of CWSB at the different rainfall patterns in coffee growing regions in Karnataka *viz.*, High (> 2000 mm), Medium (1000-2000 mm) and low rainfall areas (< 1000 mm) was carried out for two years *i.e.*, 2016 and 2017. Two estates for each rainfall regime were selected with a total of six Arabica coffee estates. The details of estates selected for the study of emergence patterns was provided in table 1.

In each location, 50 coffee plants that are infested by *X. quadripes* grubs (Plate 1) are identified based on visible symptoms on the plants with bulged rings on the stem, and small and yellow leaves, such infested plants are checked for emergence holes and confirmed that the beetle was not emerged out from the plant without exit holes. Then the infested plants without emergence holes were caged well before the start of the flight period *i.e.*, during summer first week of March retained up to August and during winter during the first week of September and retained up to February or until complete cessation of adult emergence and after infested plants are exhausted after each flight season the fresh infested plant was searched and such plants are newly caged in field next season as mentioned above.

Table 1: Details of the estates selected for studying the emergence pattern of *Xyloterchus quadripes* Chevrolat**.**

Rainfall Regimes	**Estate name**	**Place, Taluk and District**	**Avg. Annual Rainfall (mm)**
High rainfall coffee growing region (>2000mm)	CCRI, farm	Balehonnur,Koppa, Chikamagalur	2600
	Glibert Estate	Javali, Kalasa, Chikamagalur	2800
Medium rainfall region (1000-2000mm)	CRSS, Farm	Chettalii,Somavarpete, Kodagu	1600
	Brudhavan Estate	Mudigere, Chikamagalur	1500
Low Rainfall region (<1000)	Koppagodu Estate	Beluru, Hassan	800
	Mansinamakki Eatate, Blupete	Balupet, Salkespura,Hassan	800-1000

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Plate 1. Caging of borer-infested plants in fields for monitoring adult emergence

Observations on the number of beetles emerged in each caged plant at each location at weekly intervals for two years

2.2 Survey of Coffee white stem borer, *X. quadripes* Chevrolat incidence on Arabica coffee at different rainfall regimes:

A random survey was carried out to know the level of infestation and incidence of CWSB in different rainfall regimes in coffee-growing areas of Chikmagalur, Hassan and Kodagu districts from 2016 to 2017. Randomly 10 estates were selected for each rainfall regime low *viz.*, (<1000mm), medium (1000 to 2000mm) and high rainfall areas (>2000mm). The data was collected on the number of infested plants and total number of plants per acre and incidence of borer before flight season and per cent incidence was worked out (3).

2.3 Statistical analysis:

The adult emergence data were tabulated in different weeks and the experiment was continued for two years (2016-2017)and for each week was. The weather factors like maximum temperature, minimum temperature, maximum humidity, minimum humidity, and rainfall data were recorded from the study location and week wise data were tabulated. The influence of weather factors on adult emergence of CWSB was analyzed by a simple correlation study and coefficients were worked out for a period of two years. In order to investigate the simultaneous influence of the climatic factors on pest incidence, a multiple linear regression analysis was carried out. (3).

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The survey data was collected on the number of infested plants and total number of plants per acre from each plot and incidence of borer before flight season and per cent incidence was worked and subjected to the analysis of variance with RBD by using Web Based Agricultural Statistics Software Package (WASP) 2.0 version and Statistical XL tool.

3. RESULTS AND DISCUSSION

Adult emergence for a specific location is correlated with the respective weather parameters. The weather parameters are correlated in correspondence to the summer and winter flight of beetle, (Table 2), the emergence showed significant correlation in several variables. In high rainfall regime of >2000mm, maximum temperature and the minimum temperature had a significant positive correlation with adult emergence (r = 0.48 and r = 0.69 respectively). During the winter flight, maximum temperature and sunshine hours had a significant positive correlation with adult emergence (r = 0.60 and r= 0.80, respectively), whereas, rainfall, morning relative humidity, evening relative humidity and the minimum temperature had a significant negative correlation with the emergence (r = -0.82, r = -0.82, r=-0.75 and r = -0.48, respectively).

The multiple linear regression analysis between abiotic factors and the emergence of adult beetles (Table 3) indicated that all the weather parameters together influenced the adult emergence to the extent of 71 % during the summer and 89 % (R^2 values) during the winter for locations of high rainfall regions (average annual rainfall >2000mm).

In medium rainfall regions (1000 to 2000mm) annual rainfall was correlated with maximum temperature, minimum temperature had significant positive correlation (r = 0.70 and r = 0.73 respectively). Whereas the other parameters *Viz.*, sunshine hours, rainfall, morning relative humidity and evening relative humidity were insignificant. However, during winter flights, the emergence of adults had a significant positive correlation with maximum temperature (r=0.83) and sunshine hours (r=0.62). The beetle emergence was significantly negatively correlated between rainfall (r =-0.749), morning relative humidity (r=-0.594) and evening relative humidity. The multiple linear regression analysis between abiotic factors and the emergence of adult beetles (Table 3) indicated that all the weather parameters together influenced the adult emergence to the extent of 72 % during the summer

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season and 92 % (R^2 values) during the winter season for locations of medium rainfall regions of (1000 to 2000mm).

In low rainfall regions (<1000mm), maximum temperature (r=0.342) and minimum temperature (r=0.58) correlated significantly positive while others had a insignificant influence on adult emergence. With respect to the winter season, minimum temperature had a significant positive correlation with adult emergence (r =0.471), whereas, rainfall, morning relative humidity, evening relative humidity and the maximum temperature had a insignificant negative correlation with the emergence (r= -0.402, r = -0.19, r=-0.217 and r = -0.258 respectively). The multiple linear regression analysis between abiotic factors and the emergence of adult beetles (Table 3) indicated that all the weather parameters together influenced the adult emergence to the extent of 66 % during the summer season and 68 % (R^2 values) during the winter season for locations in low rainfall regions (<1000mm).

Similar findings were also reported by Sylesh and Veeresh (12) that, When the emergence of beetle was correlated with weather parameters prevailing during the particular season revealed a positive significant correlation with minimum temperature, humidity and sunshine hours. The result indicated that sunshine hours and temperature may have an intrinsic influence on the growth and emergence of CWSB beetles. Reddy (7) showed that the emergence of CWSB during the summer flight exhibited a significant positive correlation with maximum temperature and sunshine hours. While, during winter flight in contrast there was a significant negative correlation between beetle emergence and rainfall and minimum relative humidity. Also, Reddy and Bhat (8) reported that, the beetles required bright sunshine for the emergence.

3.1 Incidence of coffee white stem borer, *Xyloterchus quadripes* Chevrolat.

The incidence of CWSB ranged from 1.5 to 16% among the coffee plantations surveyed in all the rainfall regimes. During the year 2016-17 the lowest incidence (5.12 %) was recorded in high rainfall estates were statistically on par with the medium rainfall estates (7.12 %) while, the highest incidence was recorded in low rainfall estates (10.42%). Similarly during 2017 the percentage of infestation were 7.2, 8.23 and 10.81% in low, medium and high rainfall areas, respectively, and were insignificant with each other. In the survey conducted on the incidence of CWSB, the mean percentage of incidence was highest at

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rainfall <1000mm coffee growing regions, whereas in the estates of high and medium rainfall areas the percentage of incidence was found moderate ((Table 4).

Similarly, the survey carried out by Reddy (7) recorded the incidence of *X. quadripes* Chevrolat ranged from 1.5 to 8% and the mean percentage of incidence was 4.39% among the coffee plantations surveyed in Mudigere taluk of Chikmagalur, District. In case of variation in the range of infestation in all three regimes found low to very high which was mainly because of the management practices adopted and the level of shade maintained in the estate. YouSheng et al. (17) reported that, the percentage of affected trees is usually 2% to 5%, and in some years may be high as 10 to 25% depending on weather factors. Measures of integrated management of the pest are suggested and have proved effective, the percentage of local affected trees reduced from 5-10.5% to 1.5 - 3.3%.

However, Sreedharan and Vinod Kumar (13) mentioned the key issues and reasons for the variation in *X. quadripes* infestation between different plantations, *Viz.*, the expertise availability for borer tracing, uprooting and burning in different plantations varies due to unavailability of labour and most of the growers do not have irrigation facilities during summer months which cause severe water stress and coffee plants become weak and later become susceptible for stem borer infestation, as beetle lays more eggs on stressed plants. Hence, the variation in the infestation levels was observed between plantations and in different rainfall regimes too.

Table 2: Correlation analysis between weather parameters and the emergence of *Xyloterchus quadripes* Chevrolat adults from infested plants during different flight seasons 2016 -17

Serial number	Rainfall Region	Year /Flight season	Rainfall (mm)	RH (%)Morning	RH (%) Evening	Temp. Max. (°C)	Temp Min. (°C)	Sunshine (hrs)
1	> 2000mm	2016-17	-0.28	--	0.004	0.250	0.260	0.302*
	1000-		-0.182	-0.0009	-0.006	0.385*	0.027	0.16

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	2000mm							
	<1000mm		-0.154	-0.396*	-0.052	-0.109	-0.183	-0.15
2	> 2000mm	Summer	-0.187	-0.175	-0.201	0.480*	0.695*	0.178
		Winter	-0.829*	-0.82*	-0.752*	0.604*	-0.48*	0.80*
	1000-2000mm	Summer	-0.229	-0.215	-0.183	0.704*	0.735*	0.284
		Winter	-0.749*	-0.594*	-0.786*	0.83*	-0.19	0.62*
	<1000mm	Summer	-0.189	-0.409*	0.047	0.342	0.58*	-
		Winter	-0.402	-0.19	-0.217	-0.258	0.471*	-

* Significant at 5%,

Table 3: Multiple regression analysis between weather parameters and the emergence of *Xyloterchus quadripes* Chevrolat. adults from infested plants during different flight periods 2016-17

Sl No.	Rainfall Region	Flight season	Regression Equation	R^2
1	> 2000mm	Summer	y= -63.67-0.011RF+0.159RH+1.059Tmax+1.40Tmin -0.745SS	0.71
		Winter	y =27.08-0.03RF-0.25RHmorng-0.03RHevn-0.45Tmax+0.53Tmin+1.89SS	0.89
2	1000-2000mm	Summer	y = -73.13-0.002RFmm+ 0.0.044RH max + 1.84T Max + 1.06Tmin-0.609SS	0.72
		Winter	y= 27.73+0.35RF-0.32RHmorng-0.76RHeveng+3.11Tmax-1.18Tmin-0.17SS	0.92
3	<1000mm	Summer	y = -20.2067- 0.013RF - 0.404RH max + 0.194RH min	0.66

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			+ 1.01Tmax + 1.10Tmin	
		Winter	y = 35.87-0.06RF-0.50RHmorng-0.07RHmin-0.77Tmax+2.16Tmin	0.68

Table 4: Analysis of CWSB infestation level in estates of the coffee growing region under different rainfall regimes

Annual Rainfall (mm)	Average infestation of CWSB per ha				Rainfall Correlation
	2016	**2017**	**Mean**	**Range**	
<1000	10.42 (18.48)[bc]	11.19 (19.17)[a]	10.81 (18.83)[a]	2.5-16.00	-0.42
1000-2000	7.12 (15.44)[ab]	8.23 (16.67)[a]	7.67 (16.08)[a]	2-14.5	
>2000	5.12 (10.33)[a]	7.20 (13.02)[a]	6.16 (14.37)[a]	1.5 -15	
SEm±	1.36	1.50	1.48		
CD	3.93	NS	NS		

(n=30)

Note: Means followed by the same letter do not differ significantly at *P = 0.05* according to DMRT. Figures in the parentheses are arc sine transformed values

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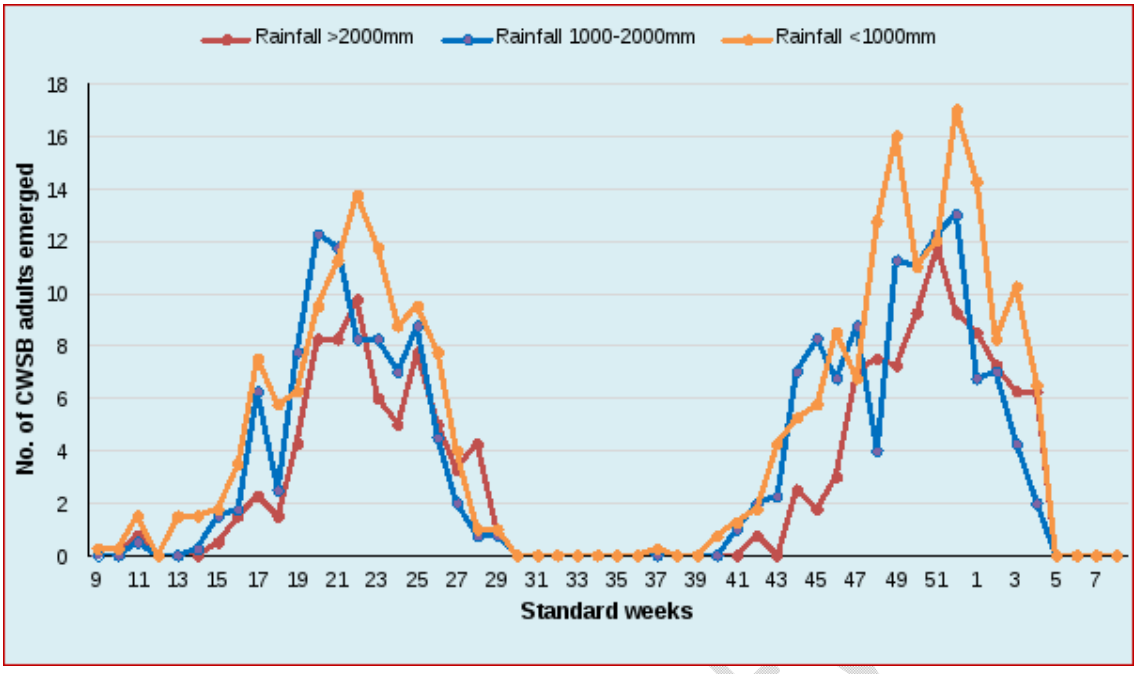

Fig. 1: Emergence of CWSB adult beetles from infested caged plants in different rainfall regions of coffee growing areas of Karnataka locations 2016-17

4. Conclusion

The emergence pattern over the three different rainfall regimes of coffee growing regions of Karnataka for two years indicated that irrespective of rainfall regimes there is a presence of two distinct flight periods in a year ie., one during April - May (summer flight) and another during October to November (winter flight) (Fig-1). The total number of beetles and number of beetles that emerged per plant at locations was comparatively higher in low rainfall regions than that medium and high rainfall. The relationship between *X. quadripes* adult emergence and weather conditions that prevailed during the study indicated that at all the different rainfall regimes the adult emergence showed a significant positive correlation with sunshine hours, maximum and minimum temperature and negatively correlated with rainfall and relative humidity. The observations made on *X. quadripes* incidence during the survey indicated maximum incidence in low rainfall areas as compared to other medium and high rainfall areas and the incidence of *X. quadripes* in all rainfall regimes ranged from 1.50 to 16.00 per cent among the coffee plantations surveyed in all the rainfall regimes.

COMPETING INTERESTS

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This is to declare that the authors have no conflict of interest in the publication of this manuscript or research data. Hence, this paper may be considered for possible publication in your esteemed journal.

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